



Advisory Circular

Subject: GUIDANCE FOR 30-SECOND AND 2-MINUTE ONE-ENGINE-INOPERATIVE (OEI) RATINGS FOR ROTORCRAFT TURBINE ENGINES

Date: DRAFT
Initiated By: ANE-111

AC No: 33-7X
Change:

1. Purpose. This advisory circular (AC) provides guidance and acceptable means, but not the only means, for demonstrating compliance with the specific requirements applicable to 30-second and 2-minute One-Engine-Inoperative (OEI) rotorcraft turbine engine ratings in part 33 of Title 14 of the Code of Federal Regulations (14 CFR part 33).

2. Applicability.

a. The guidance provided in this document is directed to engine designers, manufacturers, and modifiers.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. The Federal Aviation Administration (FAA, we) will consider other methods of demonstrating compliance that an applicant may elect to present. Terms such as “should,” “shall,” “may,” and “must” are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance in this document is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. On the other hand, if the FAA becomes aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation as the basis for finding compliance.

c. This material does not change, create any additional, authorize changes in, or permit deviations from existing regulatory requirements.

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3. Related Regulations and References.

- a. 14 CFR part 21, Certification Procedures for Products and Parts.
- b. 14 CFR part 27, Airworthiness Standards: Normal category rotorcraft, § 27.45(f).
- c. 14 CFR part 29, Airworthiness Standards: Transport category rotorcraft, § 29.45(f).
- d. 14 CFR part 33, Airworthiness Standards: Aircraft Engines.
- e. 14 CFR part 91, General operating and flight rules, § 91.3.
- f. Society of Automotive Engineering, Aerospace Recommended Practice, Certification Considerations for Highly-integrated or Complex Aircraft Systems, SAE ARP4754.

4. Background.

a. A working group composed of representatives of the FAA, the Joint Aviation Authorities (JAA), Transport Canada, and industry recommended a set of harmonized certification requirements for parts 1 and 33 applicable to the 30-second and 2-minute OEI ratings. The European Aviation Safety Agency (EASA) subsequently adopted these new requirements as part of its Certification Specifications for Engines. The proposed revisions to the certification standards for § 1.1 and §§ 33.5, 33.29, 33.67, 33.87, 33.88, 33.93, and Appendix A33.4 were published on May 4, 2007 in the Federal Register (72 FR 25207). The final rule was subsequently published as Amendment No. 33-25 on August 18, 2008 in the Federal Register (73 FR 48119). This AC provides updated guidance for meeting these requirements during certification. Prior to this amendment, the FAA adopted Amendment 18 to 14 CFR part 33 on June 19, 1996, that introduced the definitions of the 30-second and 2-minute OEI ratings for rotorcraft engines in § 1.1. It also revised specific type certification standards for the ratings in §§ 33.4, 33.7, 33.29, 33.67, 33.85, 33.87, 33.88, and 33.93. The related OEI rulemaking history is detailed in Appendix 1.

b. The 30-second OEI rating provides a short burst of high power particularly needed by a rotorcraft if one engine fails or is shut down during a critical flight configuration such as takeoff, rejected takeoff, or landing. The power levels associated with the 30-second and 2-minute OEI ratings would allow the rotorcraft to complete the takeoff or rejected takeoff with the remaining engines and continue into climbout to a safe altitude or airspeed. Similarly, these ratings are intended to provide adequate power to the rotorcraft to execute a safe landing with the remaining engines or a balked landing followed by a climbout.

c. The applicant selects the ratings from the OEI ratings specified in § 33.7. The 30-second and 2-minute OEI ratings differ from the other OEI ratings because of their higher

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power and shorter duration; their limitation to three usages during one flight; and their requirement for mandatory inspection and maintenance after use.

d. The 30-second OEI power level is considered reached when one or more of the operating limitations that apply to the 2-minute OEI power are exceeded. The 2-minute OEI power level is considered reached when one or more of the operating limitations that apply to the next lower OEI rating, or another engine rating, is exceeded.

5. Guidance.

a. Section 33.5 Instruction manual for installing and operating the engine.

(1) For rotorcraft engines having 30-second and 2-minute OEI ratings, the applicant must provide in the installation manuals the data on engine performance characteristics and variability required under § 33.5(b)(4). This data will enable the installer to meet the power availability requirements under §§ 27.45(f) and 29.45(f). The engine performance characteristics and variability should consider the power losses due to engine installation that can be defined at the engine level. For example, such installation losses should account for the effects of customer bleed and customer power extraction up to and including the highest rated power.

(2) Section 33.5(b)(4) requires that the engine be capable of obtaining and sustaining the OEI rated power while operating within the associated operating limitations. The applicant should use the required engine data to establish a procedure for trending individual engine performance. This data should support maintenance procedures, intervals, and specifications that apply to the engine, its sensors, and indicating systems.

(3) The data should also support procedures for detection of latent or dormant failure conditions of engine systems that may not be detectable through the recommended power assurance procedures or because the procedures do not include a topping check to the highest OEI rated power. For example, such latent or dormant conditions may involve the sensors and indicating systems of the fuel control maximum flow capability, measured turbine temperature, and speed limits. The applicant should analyze the dormant failures, which could lead to non-availability of the OEI rated power, and provide the results of this review for compliance with § 33.5(b)(4).

(4) The applicant should validate the adequacy of the procedures, intervals, and specifications applied to maintaining the engine, its sensors, and indicating systems on the basis of the engine and the engine system's failure modes and effects analysis (FMEA). The engine data should include a thermodynamic model, and when applicable, should incorporate the experience gained during development and certification testing, as well as field experience gained with this engine type or engine of similar design.

(5) The data required under § 33.5(b)(4) should enable the installer to establish the power assurance procedures in which the extrapolation of power assurance results can be

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achieved from a lower power level to the highest OEI rated power. The performance extrapolation may be accomplished by comparing the performance characteristics with the minimum acceptable performance for the deteriorated engine. Establishing the minimum acceptable engine performance characteristics depends on the applicant's experience with that engine and the size of its reliability database. For example:

(a) In a mature engine program, the applicant may use the new production engine acceptance test data, engine-to-engine variation, and also testing on engines prior to overhaul to determine the effects of deterioration. This program would maintain up-to-date minimum engine performance characteristics.

(b) For a new engine design or a remote derivative of an existing design, it may be more difficult for an applicant to establish the initial database. The applicant, however, could use the experience gained from the engine's development and certification tests. This experience usually includes several thousand hours of running time to schedules which are often far more rigorous than normal commercial service. The information gathered from these tests could provide a sufficient database for the assessment of in-service engines including the rate of deterioration. Testing engines in production will eventually establish engine-to-engine variation, but the applicant should assume initially an estimated worst variation based on similar experience with other engines.

(6) The applicant should also provide information on methods to ensure that engine limiter settings will not prevent the engine from reaching 30-second or 2-minute OEI power. These engine limiter settings may include engine speed, measured gas temperature, fuel flow, and torque.

b. Section 33.7 Engine ratings and operating limitations.

(1) The 30-second and 2-minute OEI power ratings for rotorcraft engines are two separate ratings defined in § 1.1. These ratings are optional and the applicant may specifically request them from the available ratings under § 33.7. In the worst-case scenario identified in the test requirements, these ratings are associated in a combined structure of 2.5 minutes duration, composed of 30 seconds at the 30-second OEI rated power immediately followed by 2 minutes at the 2-minute OEI rated power.

(2) These power ratings should be used only for completing the flight after the failure or shutdown of one engine in multi-engine rotorcraft during takeoff, climb, or landing. The 30-second OEI rated power provides a short burst of high power to complete the takeoff, or to effect a rejected takeoff, if an engine failure occurs at the critical decision point, so the rotorcraft can lift clear of any obstructions in the flight path and climb out or reject the takeoff. Similarly, this rated power provides adequate power for rotorcraft to carry out a safe landing or a balked landing if an engine fails at any point up to and including the landing decision point. The 2-minute OEI rated power provides a further period of increased power for the rotorcraft to climb out from takeoff to a safe altitude and airspeed or to perform a balked landing.

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(3) While the 30-second and 2-minute OEI ratings were originally conceived as high power ratings using the available margins in the engine design and followed by a mandatory engine overhaul, experience has shown that the manufacturers provide engines that have different capabilities and use different amount of the margins. Therefore, some flexibility is possible in defining the mandatory maintenance actions, provided the applicant appropriately validates the actions during certification (see also paragraph 5.1. of this guidance).

(4) In some circumstances, the highest power used during a 2½ minute duration event might be lower than the 30-second OEI rating power band, but still within the 2-minute OEI rating power band. In this case, the use of the 2-minute OEI rated power may be extended to 2½ minutes. However, the additional 30-second period is considered as usage of the 30-second OEI rating, and the mandatory inspection and maintenance actions prescribed for the 30-second OEI rating should be used. See paragraph 5.1.(1)(e) for additional guidance.

(5) If necessary, engine operating limitations associated with the use of the 30-second and 2-minute OEI power ratings may be established to mitigate engine failure or component deterioration observed during the applicable portion of the 2-hour supplementary test of § 33.87(f). Refer to paragraph 5.1.(1) of this AC for additional guidance.

(6) Although the certification requirements have been defined around the worst-case scenario involving the possible use of these ratings three times in one flight, these ratings are intended for one usage per flight in an emergency during takeoff or landing. We recognize that the ratings may be inadvertently used in some unexpected, non-critical conditions, such as an engine failure in a rotorcraft flying at a high-speed cruise. In all cases, the required mandatory maintenance actions apply after any use of the OEI rating powers.

c. Section 33.27 Turbine, compressor, fan, and turbosupercharger rotors. For each application for engine type certification that requests the 30-second OEI and 2-minute OEI rating before the harmonized rule for § 33.27 is issued, the applicant must comply with the existing § 33.27 rule or may request special conditions with appropriate justifications. See Appendix 2 for the technical content of previously issued special conditions amending § 33.27 that applies to the 30-second OEI and 2-minute OEI ratings.

d. Section 33.29 Instrument connection.

(1) For compliance with § 33.29(c), the 30-second OEI power level is considered reached when one or more of the operating limitations that apply to the 2-minute OEI power are exceeded. The 2-minute OEI power level is considered reached when one or more of the operating limitations that apply to the next lower OEI rating, or other engine rating, is exceeded.

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(2) The applicant must provide either a means or a provision for a means to comply with the requirements of § 33.29(c)(1) through (c)(4). For example, the applicant may satisfy “a means” by providing a recorder to record the entry into the OEI power bands. Alternatively, the applicant may fulfill “a provision for a means” by specifying that the installer provide a recorder to record entry into the OEI power bands. The applicant may find that a “provision for a means” is more suitable to satisfy the pilot alert requirement when a portion of the pilot alert system is certified with the rotorcraft. In this case, the applicant should identify this provision in the installation manual, enabling the installer to develop the required pilot alert system.

(3) The automatic recording of data required under § 33.29(c)(2) should provide the information needed to conduct the mandatory inspection and prescribed maintenance per Appendix A33.4. At a minimum, it should record each rating’s occurrences per flight; the duration for each occurrence or accumulated time; and any exceedence of the operating limitations or time limits associated with each OEI rating. See paragraph 5.b.(4) for guidance when the 2-minute time limit at 2-minute OEI rated power is exceeded.

(4) The applicant should ensure the overall development assurance level of the recording and retrieval system is consistent with its classification of at least hazardous based on failure condition classifications defined in SAE ARP4754. The development assurance level(s) for the components of systems that record the 2-minute and 30-second OEI power usages and retrieve the recorded data should be based on the criticality of the function(s) performed within the recording and retrieval system as determined by a system safety assessment (SSA). The overall system assurance level can be achieved based on an appropriate combination of system architecture and component assurance levels. The objectives are to ensure the information needed for the mandatory maintenance is available after the use of OEI powers and to avoid continued operation of the engine in a potentially unsafe condition.

(5) If the recording or retrieval system is not part of the engine, the applicant must specify in the installation instructions its required failure condition classification, system design features, and interface requirements (e.g., reliability, design assurance level, software level, lightning, and high energy radiated frequency). If software is used for data recording and retrieval, the specifications must comply with the requirements of § 33.28(g).

(6) The recording system should be designed so that only the maintenance personnel can reset it. This should prevent further engine operation without completion of the mandatory post-flight inspection and maintenance actions.

e. Section 33.67 Fuel system.

(1) The required automatic controls should be active when the 30-second OEI rated power is used and should prevent the engine from exceeding the operating limitations associated with the rating, except for the time duration discussed in paragraph

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5.e.(2) below. These limitations are established under the requirements of § 33.7 and declared in the type certificate data sheet (TCDS). They may include parameters such as the output shaft torque or power, output shaft speed, gas producer speed, and gas path temperature. Exceeding these limits could result in engine failure since the engine operation at 30-second OEI rated power could have already used most or all available margins in the engine design. An engine failure would be unacceptable in this OEI flight configuration with one engine that has already failed. The automatic control of the 30-second OEI rated power is intended to free the pilot from monitoring the associated engine parameters and ensure they remain within their limits. This is because the pilot may need to operate in a high workload environment and perform simultaneous actions to maintain a safe flight during the use of 30-second OEI rating.

(2) The applicant's design should not limit the time duration at which the 30-second OEI power is used. This would allow the pilot to exceed the time limit if needed to safely land the rotorcraft in an emergency as permitted by § 91.3(b).

(3) When, instead of the means, the applicant provides the provision for a means for automatic controls, the installation manuals should declare all necessary information for the installer to develop the automatic controls system. The means, or the provision for a means, for the automatic control of the engine within its operating limitations should be effective whether the engine operation is considered normal or abnormal.

(4) The required means or the provision for a means for automatic control should not prevent the engine from reaching and maintaining its 30-second OEI rated power.

f. Section 33.70 Engine life-limited parts. For rotorcraft engines for which the 30-second OEI and 2-minute OEI ratings are desired, the applicant should provide a method to account for low cycle fatigue effects from the use of the two OEI ratings on engine life-limited parts. This may be done by adding to the expended lives of components a finite numbers of cycles associated with the use of each of the two OEI power ratings. Alternatively, life reduction factor(s) associated with the use of each OEI power ratings may be applied to the lives of these components. Applicants with engines that were certified to § 33.14, which was removed by Amendment No. 33-22, should follow the guidance in this paragraph when applying for OEI ratings.

g. Section 33.83 Vibration test. Section 33.83(b) prescribes the required ranges of power and both the physical and corrected rotational speeds for vibration survey. For the 2-minute OEI rating, the test speed should be from the minimum rotational speed up to 103 percent of the maximum physical and corrected rotational speed permitted for the rating. For the 30-second OEI rating, the test speed should be from the minimum rotational speed up to 100 percent of the maximum physical and corrected rotational speed permitted for the rating. All other § 33.83(b) requirements apply to both OEI ratings.

h. Section 33.85 Calibration tests.

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(1) Engines having 30-second and 2-minute OEI ratings are not required to perform calibration tests, but compliance with the requirements of § 33.85 must be satisfied based on the measurements taken during the endurance test, as specified under § 33.85(d). This is to minimize the damage to the engine and its hardware during the certification program, while taking full advantage of the data obtained during the endurance test.

(2) The data acquired during testing in compliance with the requirements of §§ 33.87(f), 33.88, and 33.90 should also be used to establish the engine characteristics throughout the engine's operating envelope. In particular, the rated power for the 30-second and 2-minute OEI ratings must reflect the power deterioration observed from the test calibration prior to the endurance test of § 33.87(f) up to and including the third application of 30-second rated power. The power deterioration through the third application should be the best indicator of the worst-case power deterioration that could occur during actual use of the rating. The applicant should, therefore, include this information on power deterioration in the data given to the engine installer to enable them to define the rotorcraft performance characteristics. If power deterioration exceeds 10 percent at the 30-second rating over the course of the 2-hour test, the applicant must evaluate the mode of deterioration to ensure that the availability of 30-second rated power in service will not be compromised by deterioration variability.

i. Section 33.87 Endurance Test.

(1) For rotorcraft engines for which 30-second OEI and 2-minute OEI ratings are desired, the applicant must conduct a 2-hour supplementary test as required under § 33.87(f), in addition to the basic 150-hour endurance test. The applicant must run the test on the same engine parts, except for those defined as consumable, after completion of a 150-hour endurance test. We recommend the applicant disassemble the tested engine and inspect the engine components at the conclusion of the 150-hour test but prior to the supplementary test, using the criteria specified in § 33.93(a).

(2) The applicant should perform a second teardown inspection of the engine after completion of the supplementary test, using the criteria specified in § 33.93(b). If the applicant elects not to disassemble and inspect the engine prior to starting the supplemental test, then the teardown inspection requirements of § 33.93(a) apply on completion of the test. The level of component cleaning to facilitate inspection prior to rebuild for the additional 2-hour endurance test must be acceptable to the FAA. The applicant must show that any cleaning during the teardown inspection, or replacement of consumable parts, will not enhance the engine's ability to meet the § 33.93(b) requirements of the additional endurance test.

(3) The applicant must run four test sequences continuously for the required 2-hour test duration without stoppage. In the event of a stoppage, the interrupted sequence needs to be repeated in full or the sequence can be restarted from the interrupt point if there are technical justifications acceptable to the FAA. If it is determined that the sequence need not be repeated in its entirety, the test should be re-started from a point

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where the engine thermal condition would be the same as at the time of interruption. If an excessive number of interruptions occur, the applicant should repeat the entire test.

(4) To reduce test complexity, and to improve flexibility needed to attain the key parameters (speed, temperature and torque) during the test in § 33.87(f), maximum air bleed for engine and aircraft services under § 33.87(a)(5) need not be used if the applicant can show by test, or analysis based on testing, that the engine's ability to meet the teardown inspection requirements of § 33.93(b)(2) is not enhanced. The analysis should include (1) the effect of the bleed air extraction to the engine secondary air system which provides cooling air to various engine components; and (2) the thermodynamic cycle effects of bleed (for example, core speed to output shaft speed changes).

(5) If the power turbine accessory drives are not loaded, the equivalent power must be added (as required in § 33.87(a)(6)) to the required power at the output drive so that the power turbine rotor assembly is operated at or above the same levels it would be if the power turbine accessory drives were loaded.

(6) The engine operating limitations of 30-second and 2-minute OEI ratings must be based on the minimum values obtained during the applications of the 2-hour test of § 33.87(f) and must be identified in the TCDS. Due allowance should be made for stabilization time and the limits of accuracy for the instrumentation or automatic controlling system declared in accordance with §§ 33.29(c) and 33.67(d).

(7) The power level of test condition § 33.87 (f)(4) is intended to demonstrate the highest en route, OEI, or non-OEI power. During scheduled accelerations and deceleration, the power or thrust control lever should be moved from one extreme position to the other in not more than one second.

j. Section 33.88 Engine overtemperature test.

(1) For the purpose of the test required under § 33.88(b), the maximum power-on rpm is the steady state rotor speed associated with the 30-second OEI rating. However, if the transient speed stabilization to steady state exceeds 3 seconds, then the higher transient rotor speed achieved during the transition to 30-second OEI power should be used instead.

(2) The gas temperature increase of 35 degrees F for conducting the test per § 33.88 (b) is based on the turbine inlet gas temperature at the location immediately in front of the first stage high pressure turbine rotor.

(3) After the overtemperature test, the turbine assembly may show distress beyond serviceable limits provided that no burst, blade failure, or other significant failure of any engine component would occur, or become evident, during the test, shutdown, or subsequent teardown inspection. If a potential failure becomes evident, the applicant should analyze the failure and establish by analysis or test that the cause would not prevent the OEI rating power from being satisfactorily achieved in service.

k. Section 33.93 Teardown inspection.

(1) After the additional endurance tests of § 33.87(f), the applicant should show that no failure of any significant engine component is evident during the test, shutdown, or subsequent teardown inspection. If a failure is evident, the applicant should analyze the failure and establish by test or analysis, or both, that the cause is corrected, or certain limitations are imposed to the engine as appropriate. For this section, the engine parts that are deemed significant are those that affect structural integrity, including, but not limited to mounts, cases, bearing supports, shafts, and rotors.

(2) For components that are distressed beyond serviceable limits by this test, the applicant must show that the inspections and mandatory maintenance actions for these components specified in the Instructions for Continued Airworthiness (ICA) are adequate for maintaining continued airworthiness. The instructions should include means for proper identification of these component conditions and appropriately defined maintenance actions. The applicant should identify component deterioration during the test and the effects on the engine performance. The component distress seen as a result of the additional test should not indicate any potentially hazardous condition. The visible and non-visible physical damage should be identified and assessed, including the effects of creep, stress rupture, metallurgical effects, and life usage. The results of such evaluation should then be considered when defining and justifying the inspections and mandatory maintenance actions for the ICA.

l. Section 33.4 Instructions for Continued Airworthiness.

(1) Inspection and maintenance requirements for rotorcraft engines with 30-second and 2-minute OEI power ratings.

(a) For rotorcraft engines with 30-second and 2-minute OEI ratings, the Airworthiness Limitations Section (ALS) of the ICA is required to prescribe the mandatory post-flight inspection and maintenance actions following the use of either, or both, of these two ratings, regardless of the frequency, and prior to next flight. The ICA should also include the definition of data to be provided by the operator to support the applicant in completing the engine in service evaluation program (see paragraph 5.1.(3)).

(b) The applicant should determine the mandatory post-flight inspection and maintenance actions based on findings during certification tests, such as the endurance, overspeed, overtemperature, and maintenance tests. The applicant may also use data and information acquired during engine development tests or service experience with engines of the same or similar design. The inspection and maintenance actions required under A33.4(b)(1) should account for component deterioration and damage to ensure they are properly identified during the post-flight inspection and that adequate repairs, maintenance, or component replacement actions are prescribed. The adequacy of these inspections and maintenance actions must be validated as required under A33.4(b)(2) and their continued adequacy must be established based on an in-service program required

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under A33.4(b)(3). The mandatory inspection and maintenance actions may be modified after the engine enters service, based on its service experience.

(c) To ensure the engine is maintained in a condition so that the 30-second and 2-minute OEI rating powers can be attained and sustained, the power assurance procedures and instructions for continued airworthiness should include the following:

- 1 Recording parameters and times in maintenance records
- 2 Visual inspection(s) and results
- 3 Power assurance/trend check
- 4 Reduction in time to overhaul or component change
- 5 Addition of special inspection and intervals
- 6 Module change/overhaul
- 7 Engine removal/overhaul; and
- 8 Other maintenance details regarding servicing points, inspections, adjustments, tests, and replacement of components if required.

(d) The 30-second and 2-minute OEI ratings are intended to safely use the available engine design margins for brief periods of exposure with component deterioration permitted beyond serviceable limits and not available for further use. The extent of component damage or life reduction depends on the severity and duration of the operating conditions associated with the use of these ratings, the engine design margins, and prior hardware condition.

(e) Because the use of these ratings requires that engine operation conditions and time durations be recorded, the prescribed inspection and maintenance actions may be directly related to the actual documented usage level, time, and, if applicable, to a known condition prior to the rating(s) usage (for example, hours/cycles/prior rating exposure). Depending on the actual operating parameters, such as temperature and time exposure, recorded during the use of these ratings in accordance with § 33.29, it is possible to predefine a maintenance action that reduces the remaining time interval to the overhaul or component replacement. If the inspection mandated for the use of these ratings results in no further maintenance, then the minimum requirement would be the interpretation of recorded event data and documentation of the data in the maintenance log(s).

(f) When the 2-minute OEI rating time period is extended to 2½ minutes, the additional 30-second period is considered as usage of the 30-second OEI rating, and the inspection and maintenance actions prescribed for the 30-second OEI rating should be used. Alternately, for the extended use of the 2-minute OEI power rating to 2½-minute duration, the applicant may seek approval for different inspection and maintenance actions, also subject to the requirements of A33.4(b)(2) and (b)(3). The substantiation and validation of these actions may be based on similar engines having an approved 2½-minute OEI power rating. The applicant must show that the extended use of the 2-minute OEI power rating to 2½-minutes is equivalent to the 2½-minute OEI power rating approved for the other engine. If the applicant records only the accumulated usage time

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under § 33.29(c)(2), then the inspection and maintenance actions must be based on the total recorded time duration regardless of the number of application at the ratings used in one flight.

(2) Validation of mandatory post-flight inspection and maintenance.

(a) The mandatory inspection and maintenance following the use of 30-second or 2-minute OEI ratings should identify and correct any component distress that could significantly reduce subsequent engine reliability or prevent the engine from achieving or sustaining further application of the OEI ratings. The applicant should provide evidence by endurance test results, analysis based on test data of the endurance tests, and/or certification tests and service experience of similar engine types and designs to show that power at 30-second and 2-minute OEI ratings is achievable and can be sustained for the respective duration during the intervals between overhauls or major maintenance of the engine.

(b) The certification procedures for 30-second and 2-minute OEI ratings demonstrate the design adequacy by endurance testing and by specific margin tests for turbine temperature and rotor speeds. Essential to establishing mandatory inspection and maintenance instructions is a thorough knowledge of the potential damage incurred with use of the 30-second and 2-minute OEI ratings. The applicant should demonstrate a good understanding of the engine operating margins to various failure modes when using the 30-second and 2-minute OEI ratings. These failure modes and margins should be determined and validated by appropriate methods or experience. These may include but are not limited to:

- 1 Design analytical predictions
- 2 Service experience of identical or similar design
- 3 Test or service failure experience
- 4 Results of OEI certification tests
- 5 Dedicated engine and component tests; and
- 6 FMEA predictions.

(c) Understanding of failure modes may come from service experience in which hardware distress or failure was caused by known exceedence operation. Alternatively, either component or engine level exceedence testing could be useful in evaluating failure mode margins, indications, power decay characteristics and severity. Existing methods to establishing failure margins are specific to a certain engine design and experience and, therefore, vary greatly between engine types. One test method that illustrates the objective of assessing the failure margin(s) from the 30-second OEI power rating condition is to progressively increase engine fuel flow until either an abrupt failure occurs or power begins to decay due to component degradation. Results of such a test could establish margins to and consequences of component failure. This could be useful in establishing appropriate maintenance instructions. Potential failure modes are design dependent, however, most are related to excessive turbine temperature or engine overtorque. Some potential failure modes could include but are not limited to:

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- 1 Blade stress rupture
- 2 Vane distortion/area change
- 3 Case distortion
- 4 Disc, spacer, or seal growth/rub
- 5 Creep
- 6 Incipient melting
- 7 Rub induced HCF; and
- 8 Blade release.

(d) The applicant should provide mandatory inspection procedures that can reliably ascertain component distress and continued airworthiness; define life reduction; or require certain component replacement, repair, or overhaul. An applicant that has an extensive service history with derivative engines can combine that experience with OEI test results and failure mode/margin knowledge to establish the maintenance requirements with a high degree of confidence. A new type design may have to rely on design/FMEA predictions, development/certification/flight tests, and dedicated failure mode test experience to form the basis for establishing OEI usage maintenance requirements. These initial requirements could be altered later based on documented service experience and or additional development tests.

(3) Program to Validate Continued Airworthiness Instructions and Power Availability.

(a) The in-service engine evaluation program required under A33.4(b)(3) ensures the continued adequacy of the airworthiness instructions and power availability. To achieve this goal, the applicant should collect data related to the condition of engine hardware and power availability at various stages in the life of the engine. The applicant should verify that the data satisfactorily compares with that used to define the mandatory post-flight inspection and maintenance actions at the time of engine certification. When comparing data from the in-service engines that experienced the 30-second and 2-minute OEI ratings use with data from the certification engine following the 2-hour endurance test required under section 33.87(f), the applicant may find differences in hardware condition and power assurance characteristics. The applicant must ensure that any of these differences are properly addressed and accounted for by the mandatory inspection and maintenance actions required under this section. Otherwise, these differences, the in-service engine data, or any other supplementary data obtained by additional engine test, should be used to modify the mandatory instructions.

(b) The applicant should identify in the ICAs the type of data and the procedures to collect and return the information necessary for the in-service evaluation program. To decide what data should be collected, the applicant should consider the following:

- 1 Whether the engine is a new type design, a derivative, or a derivative of a previously certified engine with 30-second and 2-minute OEI ratings.

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2 The applicable service experience with identical or similar engine designs.

3 The certification and development test results indicating whether the OEI ratings are aggressive or conservative, or whether the use of the ratings causes additional distress or no distress to the engine hardware.

4 Knowledge of failure modes and margins to failure.

(c) The in-service engine evaluation program must include some type of service engine testing and/or evaluations of service usage of the 30-second/2-minute ratings, although equivalent service engine test experience on engines of similar design is acceptable as an alternative. This part of the program would consist of, but not be limited to, one or more of the following elements:

1 Scheduled tests of in-service engines consisting of three applications of the 30-second OEI rated power, while either installed in the rotorcraft or in an engine test cell. The engines should be selected to have sufficient service time to meet the goal described in paragraph (a) above. The program should specify the test frequency and the number of engines to be tested, as well as test parameters, necessary inspections, and data to be recorded. At a minimum, the recorded data should relate to the available power, power assurance validation, and hardware condition before and after the 30-second and 2-minute OEI rating usage.

2 Unscheduled opportunity tests of engines consisting of three applications of the 30-second OEI rated power. The program may include actions to be taken when engines become available that meet certain predetermined criteria. Definition of selection criteria for representative aged engines should be included in the program. Inspection/test requirements on such engines should include the recording of data related to available power and the identification of the hardware condition before and after the 30-second and 2-minute OEI rating usage.

3 Service usage of 30-second/2-minute OEI rated power. This may include recorded power available data, post usage of OEI rating power available data, and results of the mandatory inspection and maintenance actions.

4 Tests of in-service engines of similar design are also acceptable, providing they are shown to be equivalent or representative.

(d) The number of the in-service engines tested may be reduced if justified by the data obtained during the engine development or certification tests. Engine data obtained during the rotorcraft certification testing of the 30-second and/or 2-minute OEI ratings may be also used when it applies to engine available power and the hardware condition. Although the number of engines tested may be reduced based on certification data, the in-service engine tests under this program cannot be eliminated.

(e) During the execution of the in-service engine evaluation program, the applicant should modify the continuing airworthiness instructions as needed based on the

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results obtained. Similarly, if circumstances warrant, the program may need to be modified as additional in-service data becomes available.

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Appendix 1. Rulemaking on OEI Ratings

1. The Aerospace Industries Association of America, Inc., (AIA) submitted a petition for rulemaking to the FAA on September 20, 1984, requesting an amendment to part 33 to permit type certification of engines and rotorcraft with new 30-second OEI and 2-minute OEI ratings.
2. As a result of the AIA petition, the FAA issued Notice of Proposed Rulemaking (NPRM) No. 89-27 and Supplemental Notice of Proposed Rulemaking (SNPRM) No. 89-27A, published in the Federal Register on September 22, 1989 (54 FR 39080) and February 7, 1995 (60 FR 7380), respectively. The NPRM proposed definitions and type certification standards for 30-second OEI and 2-minute OEI ratings at higher power levels than those currently available. In response to several comments, the FAA issued the SNPRM, which proposed modified definitions to 30-second OEI and 2-minute OEI ratings and minor wording changes to §§ 33.29, 33.67, and 33.85. The SNPRM also proposed a second overspeed test requirement in § 33.27 for 30-second OEI and 2-minute OEI ratings.
3. The final rule (Amendment 33-18) was published in the Federal Register on June 19, 1996 (61 FR 31324). In the final rule, the FAA adopted the proposed new definitions of 30-second OEI and 2-minute OEI power ratings. The FAA also revised requirements related to OEI ratings in §§ 33.7, 33.29, 33.67, 33.85, 33.87, 33.88, and 33.93. The proposed change to § 33.27 was not adopted because the FAA determined that certain technical aspects had not been resolved and were still under discussion with the Aviation Rulemaking Advisory Committee harmonization working group. The FAA indicated in the final rule that the overspeed test requirements for the ratings would be addressed on a case-by-case basis for each application for type certification that requests 30-second and 2-minute OEI ratings. Four special conditions that addressed overspeed test requirements for 30-second OEI and 2-minute OEI ratings for certain specific engine models were issued between 1993 and 2006.
4. The FAA has amended the One-Engine-Inoperative (OEI) rating definitions and type certification standards for 30-second OEI and 2-minute OEI ratings for rotorcraft turbine engines. On May 4, 2007, the FAA published a notice of proposed rulemaking (NPRM) titled “Airworthiness Standards: Rotorcraft Turbine Engines One-Engine-Inoperative (OEI) Ratings, Type Certification Standards” (72 FR 25207). The final rule was published as Amendment No. 33-25 in the Federal Register on August 18, 2008 (73 FR 48119). This action revises the ratings’ standards to reflect recent analyses of the ratings’ use and lessons learned from completed engine certifications and service experience. This rule harmonizes FAA type certification standards for these ratings with the requirements of EASA in the Certification Specifications for Engines and with proposed requirements for Transport Canada Civil Aviation, thus simplifying airworthiness approvals for import and export.

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Appendix 2. Example of Special Conditions for Overspeed Test Requirements of § 33.27

1. The following is an example of the technical content of special conditions to § 33.27(b) for the 30-second OEI and 2-minute OEI ratings. For engines with 30-second and 2-minute OEI ratings, in addition to the requirements of § 33.27(b), turbine and compressor rotors should have sufficient strength to withstand the conditions specified in one of the following tests for the most critically stressed rotor component of each turbine and compressor, including integral drum rotors and centrifugal compressor, as determined by analysis or other acceptable means. We recommend selecting the test from the following paragraphs (a or b), as determined by the speed defined in paragraph a(2) or b(2), whichever is higher.

a. Test for a period of two and one-half minutes—

(1) At its maximum operating temperature except as provided in § 33.27(c)(2)(iv);
and

(2) At the highest speed determined, in accordance with § 33.27(c)(2)(i) through (iv).

(3) This test may be performed using a separate test vehicle as desired.

b. Test for a period of 5 minutes—

(1) At its maximum operating temperature except as provided in § 33.27(c)(2)(iv);
and

(2) At 100 percent of the highest speed that would result from failure of the most critical component of each turbine and compressor or system in a representative installation of the engine when operating at 30-second and 2-minute OEI rating conditions; and

(3) The test speed must take into account minimum material properties, maximum operating temperature, and the most adverse dimensional tolerances.

(4) This test may be performed using a separate test vehicle as desired.

Following the test, rotor growth and distress beyond dimensional limits for an overspeed condition is permitted for 30-second and 2-minute OEI ratings only, provided the structural integrity of the rotor is maintained, as shown by a procedure acceptable to the FAA.